Weatherwise

Some Phases of Waterspout Behavior

The Hay Fever Season in New York City

The Weather and Climate of Korea

A Phenomenal Haze in the Pacific

Long Island Weathermen

Vol. 3, No. 4
AUGUST, 1950

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE" — BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

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NOTES ON RAINMAKING

NEW MEXICO has become the first state to start an official investigation of artificially induced rainfall. The economic development commission has authorized the New Mexico School of Mines to make a four-month study of all aspects of rainmaking. The project will attempt to co-ordinate the efforts of many individual rainmakers throughout the state. Much "wildcat" rainmaking during the past may have been detrimental to other attempts. A group of farmers in Carrizozo, New Mexico, has formed a co-operative to finance the seeding of a 3,000-square-mile area.

New York reservoirs enjoyed excessive rainfall during the first half of July. At the Croton watershed a catch of 5.85 inches was more than double a normal of 2.38 inches. In all, the New York system on July 15th was at 92.3 per cent of capacity as compared to 84 per cent a year ago, when severe drought conditions existed. The counties in the vicinity of the Catskill watershed have formally protested to New York City to secure an end to rainmaking in their vicinity. Farmers in the area declared that the overabundance of rain recently had damaged their crops.

Rainmakers in California were given credit for dousing two forest fires there early in July. Seeding was done from the air by a plane on permanent rainmaking duty with the California Electric Company.

Rainmakers in Washington State were given credit by their rancher employers for increasing the June rainfall over the Prosser area by 435 per cent, as a result of cloud seeding by silver iodide over their 100,000-acre wheat holdings. On two occasions the rainfall pattern of the entire region was altered, and the Horse Heaven area received over an inch of rain while surrounding places were getting only a quarter of an inch, which is about normal.

In Arizona, the press reports seeding projects under way over the Navajo Indian Reservation, over sections of the Upper Verde River, and in the Willcox area in the southeast. Charges are reported as from four to six dollars per square mile. Heavy rains fell throughout the state in early summer in both seeded and non-seeded areas, largely as the result of a tropical air mass that drifted into Arizona from a hurricane that dissipated off the tip of Lower California.

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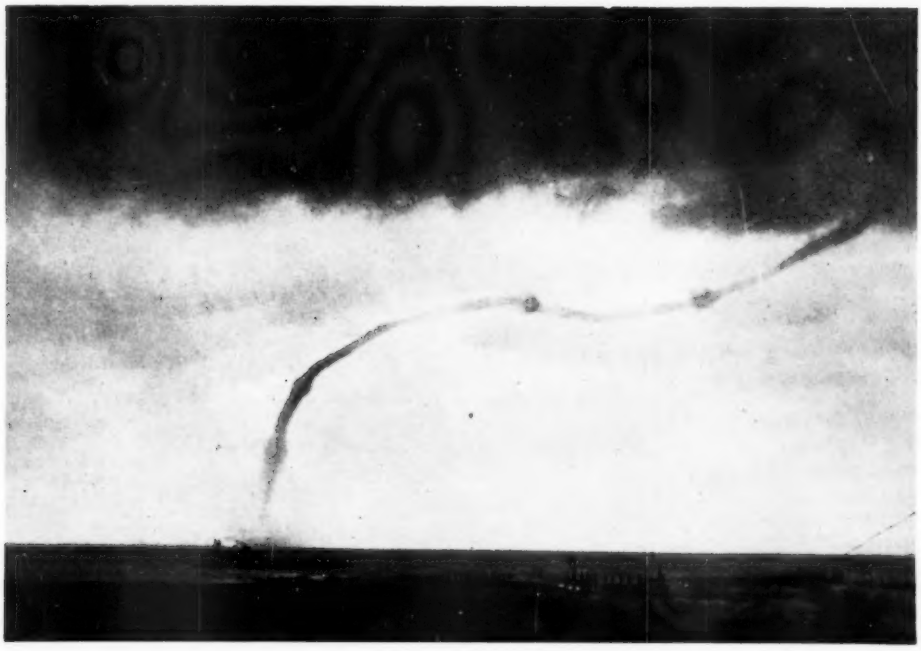
Cover: A waterspout photographed at 1330 GMT by an Air Weather Service pilot, Lt. R. W. Field, Jr., when returning from a weather reconnaissance mission over Germany on November 11, 1944. When about 25 miles off Ancona, Italy, he noticed two large waterspouts and several incipient ones disturbing the surface of the Adriatic Sea. The picture was made below a 2,000-foot base of cumulonimbus clouds, half a mile to the east of the waterspout. It was estimated to be about 200 feet in diameter, tapering in its lowest 100 feet and ending in a needle point on the sea (obscured by spray in the picture). U. S. Air Force photograph.

WEATHERWISE is published bimonthly by Amateur Weathermen of America, Franklin Institute, Philadelphia 3, Pa. Membership in the AWA costs $3.00 per year, of which $2.00 is for a subscription to WEATHERWISE and $1.00 for general dues, for members in the United States and possessions and in the armed services. Add 50 cents per annum for postage to Canada and all countries of the Pan-American Postal Union; add $1.00 for all other foreign countries. Make checks and money orders payable to Amateur Weathermen of America. Send notice of change of address three weeks in advance, giving old address. General, circulation, and advertising offices: Franklin Institute, Phila. 3, Pa.



Peculiar knots at irregular intervals characterized this tornado waterspout at Lavaca Bay, Texas, on July 1, 1942. U. S. Weather Bureau photograph.

Some Phases of Waterspout Behavior

WILLIS EDWIN HURD, USWB RETIRED

DURING more than half of the 39 years in which the writer was officially connected with the United States Weather Bureau, he considered himself very fortunate in being assigned to its marine meteorological work. He was in close touch with a vast number of ship weather reports, many of them containing special accounts of miscellaneous phenomena noted by the observing officer, such as mirages, fog, particular storm conditions, and waterspouts. Thus, over many years, a vast fund of specialized information was secured by the bureau, ready for the intensive study of an employee who might be given the opportunity to delve into the mass and draw from it the nuggets which pertained to his particular line of inquiry. The opportunity and I luckily advanced to meet each other, and during many years thereafter the textual results of my delvings found publication on the United States Hydrographic pilot charts of the oceans, issued monthly for the information and guidance of all maritime interests.

Among the most fascinating of my studies was that pertaining to oceanic waterspouts. Some data on the subject had already seen publication from time to time, but the literature pertaining to it was far from abundant. But when I had gathered many hundreds of manuscript items relating to spouts at sea, I had an almost exhaustive fund of material upon which to draw.

Land tornadoes, relatives of waterspouts, generally form along the boundaries of conflicting warm and cold air masses. Oceanic waterspouts, however, may vary greatly in their appearances, activities, and originating causes. They, too, may form along squall lines of opposing air masses, under storm conditions, but they appear as well with more-or-less settled weather. Convection may

be active or a flat calm may exist at the surface. Their causes are indeed often far more complex than simple, and in some instances may be impossible to determine.

The average land tornado is probably much more intense than the average large waterspout, and a tornado lasts longer and moves faster. Waterspouts rarely last for more than an hour or so; the great majority form and disperse within a half hour, while some complete their life cycle in two, three, or five minutes.

The tornado of the Northern Hemisphere probably invariably rotates cyclonically, that is, counterclockwise as seen from above. Waterspouts, unless they form under like conditions along air mass boundaries, may whirl in either direction. They may result from factors similar to those that form the dust whirls of the sandy plains or the deserts, which also may rotate either way.

With tornadoes there must exist storm clouds; with waterspouts, as with sand whirls, some of the convective variety may form without a cloud in the sky. Most spouts, however, require cumulus, stratus, stratocumulus, or cumulonimbus clouds as their initial base of action. But, while the greater number of spouts form at the cloud level, with some rising initially from the sea surface, others seem to begin, fairly simultaneously, at both ends. They behave as though a column of gyrating air had come into sudden existence, spanning the space between sea and sky.

A waterspout about a mile offshore at Deerfield Beach, Florida, photographed August 1, 1940, by Mrs. Martha M. Sait. Note the dark inner core and the light outer one. U. S. Weather Bureau photograph.

In such cases, opposing winds within the cloud form an eddy, which begins to appear as a downward projecting bulge, the cloud seeming to boil about the protuberance. This lengthens seaward in an irregular, pulsating manner, but it has not gone far toward the surface when the water begins to be disturbed below it and an eddy is there created. In the center of the eddy the water boils and may begin rising into a mound. From the ring of the eddy rises a misty envelope, into or around which rushes spray from the agitated wavelets. There is now a rising dark and ominous spout on its way to meet the part descending from above. Finally the two join, the whirling motion in the completed tube attaining its greatest violence. The fully formed spout moves on its way to the accompaniment of roaring winds along its length.

Before the two parts of the spout come together, the intermediate air has taken on a spiral motion, though unseen, but with the lowering of the central pressure the air cools. The warm, humid air of the ring therefore begins to condense its moisture until the entire spout comes into view as a dark gray to almost black column.

Some water other than that of condensation is inevitably carried up for some distance by the suction of a well-developed spout. An occasional vessel, caught in the downpour of rain resulting from the disintegration of a strong waterhose, has reported saline showers. There is the sufficiently verified report concerning an aftermath of the truly gigantic and frightful waterspout that occurred in Vineyard Sound, Massachusetts, on August 19, 1896. Two or three hours following its dispersal, while rain was falling from the heavy clouds in which the monster had earlier formed, the residents of Martha's Vineyard Island were treated to a

The gigantic waterspout over Vineyard Sound, August 19, 1896, estimated to be about a sixth of a mile in diameter at the cloud base. U. S. Weather Bureau photograph, by J. N. Chamberlin, from Cottage City, Massachusetts.

salty downpour, proving that sea water had been carried up the approximately 3,000-foot tube in substantial quantity and spread throughout the clouds themselves.

Some waterspouts associated with thunderstorms have given showers of hail when breaking up. One vessel on the Grand Banks, April 10, 1888, during cyclonic conditions, observed a number of waterspouts. The ship was close by the largest of the spouts when it broke up, and the ship was showered not only by rain and hail but by irregular chunks of ice, some of them four to six inches in diameter, according to the record.

The process of waterspout disintegration is usually the reverse of its growth. The rotating winds slacken and condensation lessens, until the whole phenomenon disappears.

Spout lengths and diameters vary widely. They may be a yard or less in thickness, or huge and dense, like the Cottage City whirl in Vineyard Sound, which was figured by a scientific observer as no less than 144 feet thick at its narrowest part, and 840 feet at the cloud base. Occasionally a spout has a span between sea and cloud of close to a mile; one such was observed by sextant measurement. Some are but a few feet in elevation, shaped much like a huge barrel or a buoy, rising from the surface in vapory to watery gyrations.

Among strange waterspouts have been seen a curved one with a great bulge in the upper center of it and another with so complicated a twisting motion that it doubled upon itself, and when the coils made contact the entire formation immediately broke up and disappeared. In the spiraling of sea water up

the flue, instances have been reported showing that while the liquid most often rises along the outside of the pipe, it sometimes goes up within the low-pressure core. In a few cases, a secondary core has been reported inside of the primary one.

Not all funnels carry up sea water. Only those with the highest gyrating velocities and the strongest suction may do that. The funnel walls are often described as thin and composed only of condensation vapor, whirling at so low a velocity as to be incapable of doing damage except perhaps to a small boat. A naval vessel passed through one of these fog pillars in the West Indies, and observed in it no high wind, only enough to sustain moderate condensation, which blew upon the ship as a damp mistiness. By contrast, one may find in the tales of old sailing ships narrations of spouts that fell upon vessels unable to escape them and either sank them or keeled them over, by the force of wind and water. In one example, out of many similar ones, a ship struck by a spout reported a strong gale from one compass point as blowing on its forward deck, while the afterdeck had a gale from the opposite point. Amidship, in the center of the whirl, was a suffocating calm.

A fully developed waterspout consists of the central mound, or sometimes depression, at the surface of the water; the cascade, or bush, of heavy spray thrown out from the base of the whirl; the hollow whirling tube itself; and the projecting breast at cloud level from which the spout extends. The basal mound is doubtless the result of the greatly lowered pressure in the center of the whirl and the consequent bulging up of the water surface there. The depression occasionally observed instead of the mound is thought to be caused by a strong downrush of air along the lower part of the tube, an unusual feature in waterspouts and one little understood. The cascade is so violent in a powerful spout that great amounts of spray may sometimes be hurled for many scores of feet into the air. The outrush of water in such a spout has been known to cause a veritable floodburst on the deck of even a large vessel, especially terrifying when the phenomenon occurs at night and dashes upon the vessel without previous warning.

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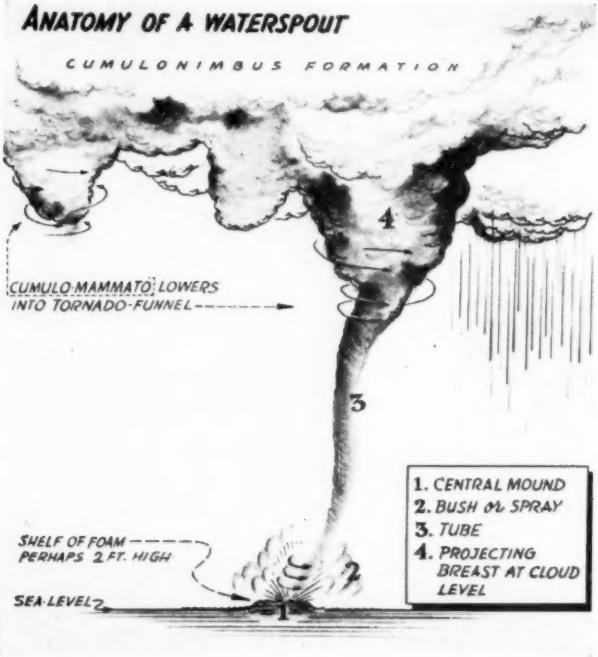

The details in this drawing of the anatomy of a waterspout may be compared with the photographs in this article, and with the front-cover illustration. Drawing by Eric Sloane.

THE HAY FEVER SEASON IN NEW YORK CITY

WILLIAM C. WOODWORTH AND RICHARD D. WISEMAN, M.D.

FOR THE SEVERAL MILLION hay fever victims the summer months spell a season of varying degrees of discomfort. The primary cause of most symptoms is the prevalence in the air of small particles of pollen, ranging in size from 15 to 60 microns. One of the most troublesome sources of hay fever is caused by ragweed, a weed very common in suburbs of metropolitan areas and untended farmland. Intensified efforts are being made by certain scientific agencies to discover, through pollen surveys, the main sources of the offending pollens.

One such group studying the various phases of pollen distribution is the allergy division of the Jewish Hospital in Brooklyn, headed by Dr. Matthew Walzer. This group has completed 14 years of pollen counting in Brooklyn and four years of an intensive survey of metropolitan New York.

The basic data in the pollen investigation program in New York City is obtained from observations made at 15 to 20 representative stations, where a device called a sampler measures the pollen in the air for each 24-hour period. Developed by Durham, the device consists of a small shelter in which a greased glass slide is exposed daily to catch the pollen in the air. An area on the slide measuring 3.6 square centimeters is counted in order to determine the count per cubic yard of air for each 24 hours. This technique for pollen sampling is known as the gravity slide method. The shelters are placed at strategic points — usually on high unobstructed roofs of hospitals, firehouses, weather stations, and other municipal buildings, where personnel can change the slides regularly at nine o'clock every morning. The exposed slides are forwarded to the allergy laboratory at the Jewish Hospital for counting.

With most hay fever victims, symptoms will develop when the pollen count reaches 10 to 20 grains per cubic yard of air. In New York City such conditions may be anticipated on 18 to 25 days during late August and early September, though there is considerable variation at different locations within the metropolitan area. The season's total pollen count for New York City may be judged from the 1947 total of 1,400 grains per cubic yard of air. This figure is not considered high, for some localities in other parts of the country have total counts 10 times that much. New York benefits somewhat by its proximity to large areas of water to the south and east, which precludes the probability of wind-borne pollen coming from those directions. Furthermore, the scarcity of suitable areas for the growth of ragweed within the city limits reduces the supply of pollen from strictly local sources.

Weather factors play a vital part in the occurrence of pollen in the air. Once the pollinating season is under way in New York City, wind was observed to be the most influential factor in producing a high count of pollen. In a series of tests conducted from aircraft and ships at sea, it was found that pollen may be carried from 200 to 600 miles. Significantly, in New York City the highest pollen counts occur with or just following the transport of air from the west or a westerly component wind.

Last year the highest count of pollen occurred on September 1st. The chart shows the weather pattern for that date. The rather strong westerly flow of air evidently stirred up pollen from beds in New Jersey and dispersed it over Greater New York. The count

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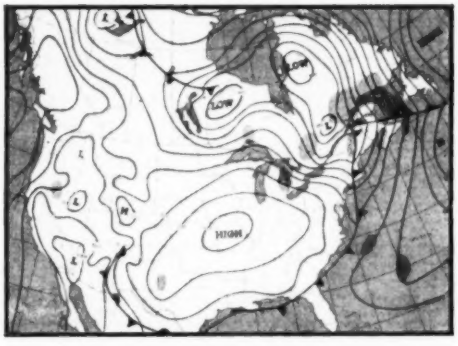


The weather chart for 1:30 p.m. September 1, 1949, when westerly winds brought the highest pollen count of the year to New York City. USWB chart.

The Weather and Climate of Korea

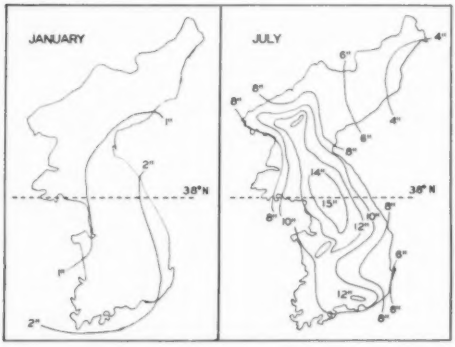
DAVID M. LUDLUM

THE FAVORITE NAME of the Koreans for their mountainous homeland is Chosen, meaning Land of the Morning Calm. Though this may be correct, meteorologically speaking, no visiting American these days would call the description very appropriate.

Weather is an all-important factor in war, and probably the one least given to long-range prediction. In the Korean area, however, one can safely make extended period forecasts — the summer months are the worst possible ones for combined air, sea, and ground operations, and the winter months, conversely, are highly favored for military operations.

The salient feature in the climatic controls of Korea is that it is an easterly projection from the greatest world land mass into the world's largest body of water. Thus, it is subject to monsoon control, with a distinct continental regime in winter and a distinct maritime dominance in the summer months.

The peninsula of Korea is small, extending 600 miles from north to south and averaging about 135 miles in width. But it has a widely varying climate, both from region to region, from season to season, and, at times, even from day to day. On one side, the relatively cool, deep waters of the Sea of Japan greatly modify and transform traveling air masses; and on the other side, the relatively warm, shallow Yellow Sea attracts and nourishes migrating cyclones. In addition to the double maritime exposure, the Korean terrain is broken up by a long mountain chain that runs lengthwise and also at several points crosses the peninsula. Thus, the mountain barriers and the large bodies of water create distinct climatic provinces and cause great variations of weather within short distances.



A comparison of mean precipitation in Korea for January and July, from "A Climatic Summary of Korea."

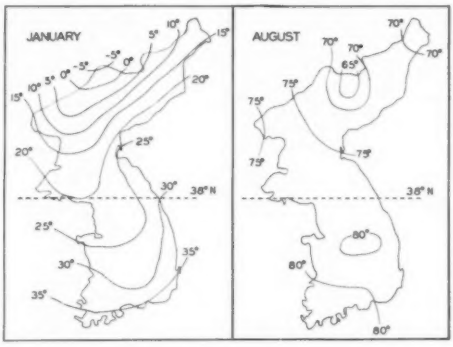
Korea's latitudinal position between 34° N. and 43° N. is far enough north to come under the influence of the westerly jet stream of air flow that steers cyclonic disturbances around the globe in the middle latitudes. Yet it is also far enough south to encourage visitors from the tropics in the form of typhoons, probably the greatest forces nature generates in the earth's atmosphere.

Typhoons, however spectacular, are not the chief obstacle to current military operations. During the summer months, tropical and even equatorial air masses penetrate as far north as the Korean coast, and often the polar front, separating Siberian air (cold and dry) from low-latitude Pacific air (very warm and very moist) lies in a quasi-stationary position over the peninsula for weeks at a time. This front is rather diffuse and shows up on the weather map as a shallow trough, yet rainfall may be very heavy and may continue for many days at a time. Mean monthly rainfall runs up to 16 inches for July at several points, and an extreme fall of 42.7 inches was recorded at Sinkei (elevation 197 feet) during the month of August, 1922.

The tropical air masses begin to take over the situation in late May and generally hold through September. It is in this period that the Siberian land mass is covered by a vast low-barometer area, and a great drift of air, known as the monsoon, is set in motion by the strengthening and westward extension of the Pacific high. Winds during the summer monsoon are always onshore from the south and southwest, although the many mountain barriers and bodies of water may cause local variations from the general pattern.

The summertime, too, is the season of greatest cyclonic activity in central east Asia — about 78 per cent of all the lows moving across Korea occur in the six months from

April to September. With the presence of air masses of extremely high moisture content (the relative humidity averages near 90 per cent at coastal locations), the employment of a rainmaker in Korea has never been contemplated. In fact, there was so much rain in the times of the early Korean king-



Mean temperatures in Korea for January and August, from "A Climatic Summary of Korea."

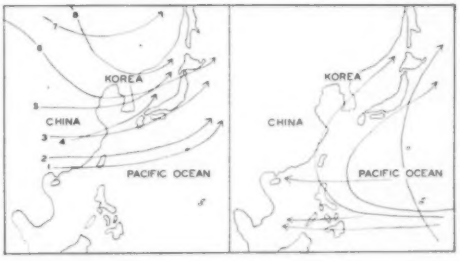
dom that the ruler ordered a scientific rainfall survey employing the earliest known rain gages as far back as 1442 A.D., in order to straighten out the minds of his subjects, who thought that there was some connection between the rain gods and the royal family of Korea.

Summer temperatures run high, with the July-August mean above 80° F. in many southern points. The all-time high appears to have been 103° F. at Taegu in the southern interior, where the reputed morning calm is featured. High temperatures, excessive humidities, and low wind movement in the current season are hardly conducive to the efficient operation of men or equipment in military campaigns.

In wintertime, all the weather elements reverse themselves. Then the flow of air is out of the northwest and north as the gigantic Siberian high often builds up to a barometer of 31 inches and more. From November to March there is a constant stream of cold, dry air available. The polar front lies far to the south in China, and the 32° F. isotherm of the daily mean extends almost to the south coast of Korea. Pusan, the south coast seaport, experiences temperatures similar to those of Washington, D. C., while in the north they are the same as in a North Dakota winter — the January mean at Chunggangjin is −6° F., with an extreme reading in the nearby mountains of −44° F. Snow falls to a depth of 18 to 36 inches in the north, and every winter will see snowcover all the way to the southern coast, although it may be of only a few hours or days duration. The air is very dry, with cyclonic activity at a minimum, and snowfall is only moderate in most areas.

Trajectory is everything in Korean weather. If the Siberian high migrates eastward, as it often does in late winter, winds on the east coast will then be out of the northeast, onshore from the Sea of Japan, which quickly transforms dry continental air into maritime air with resultant low cloudiness and light precipitation. Thus, a small shift in the wind may bring great variation in winter conditions. Pilots have learned that the trajectory of the air flow may cloud in the west coast and leave the east wide open, and vice versa.

Spring and fall, of course, are transitional months when anything can happen. Though the northwesterly regime may be expected to take over in early September, there may be relapses; several late-season invasions of tropical air may take place. In fact, the travel folders say October is the ideal month for the traveler, and perhaps our military planners have read up on the subject. In spring, again, there is an ebb and flow in the conflict of air masses, and conditions vary considerably. Among the many Korean proverbs about the weather, there is one to



Left: Storm tracks of east central Asia. 1-4, central China depressions; 5, Siberian secondaries; 6-8, Siberian depressions.

Right: The tracks of typhoons in the western Pacific, some of which cross Korea.

the effect that three cold days follow four warm ones.

Military operations on the ground are least favored during the summer season of rain, heat, and humidity. The soil of the southern area is covered by flooded rice paddies, and the only suitable areas for heavy equipment are the levees of streams, canals, and the railroad beds. Later in the year conditions improve immeasurably, especially in the north, and by mid-December the soil is usually solidly frozen as far south as the 38th parallel. Rivers in the north also freeze, but snowcover again hampers the movement of wheeled vehicles.

In air warfare the summer is also the worst possible season, for cloudiness, usually of the low stratocumulus type, averages around 80 per cent. High-level bombers are usually forced to resort to bombing by radar, and low-level attacks are hindered by poor visibility and treacherous mountain terrain. Air strips, unless paved, may be inoperative for days at a time during the rainy season. In winter, CAVU conditions prevail about 70 per cent of the time, and airmen are happy.

Amphibious operations in the area have many hazards, too. The east coast is rocky, with few beaches, and there is a vast mountain barrier immediately inland. The west coast has many small islands and a great tide that runs from 20 to 36 feet to complicate the job of the landing craft skipper. Gales occur about six days per month in winter, especially in the Korean Strait, and may continue for several days at a time, often with blizzard characteristics.

SOME PHASES OF WATERSPOUT BEHAVIOR

(Continued from page 78)

Waterspouts form on all the oceans, from the polar regions to the equator, and may occur in all months, though most frequently from May to September, except that July seems to be a slack month. Favorable regions for their occurrence in the North Atlantic are over an area stretching from the Gulf of Mexico, the Caribbean Sea, and up along the Antilles and the westernmost course of the Gulf Stream; in the equatorial southeast toward the African coast; and within and along the edges of the doldrums, where the trade winds are fitful, or disappear, and calms, high humidity, and convection currents are prevalent. But when or where one might expect to observe a waterspout during an ocean voyage is quite another matter.

Waterspouts have originated on lakes and rivers in the United States and elsewhere, and now and then a waterspout may go ashore and become a land tornado, as a tornado may cross one of the Great Lakes and turn into a waterspout.

Spouts may come singly or in groups, according to the spread of the favoring weather factors. From an elongated cloud in Bahamian waters, for example, a whole string of spouts has sometimes been observed, from those fully formed to short, incipient inverted cones which hang pulsating from the stratocumulus base.

All in all, the waterspout, or waterhose, is a most singular, erratic, curiously behaved, and at times dangerous and awe-inspiring creature of the sea.

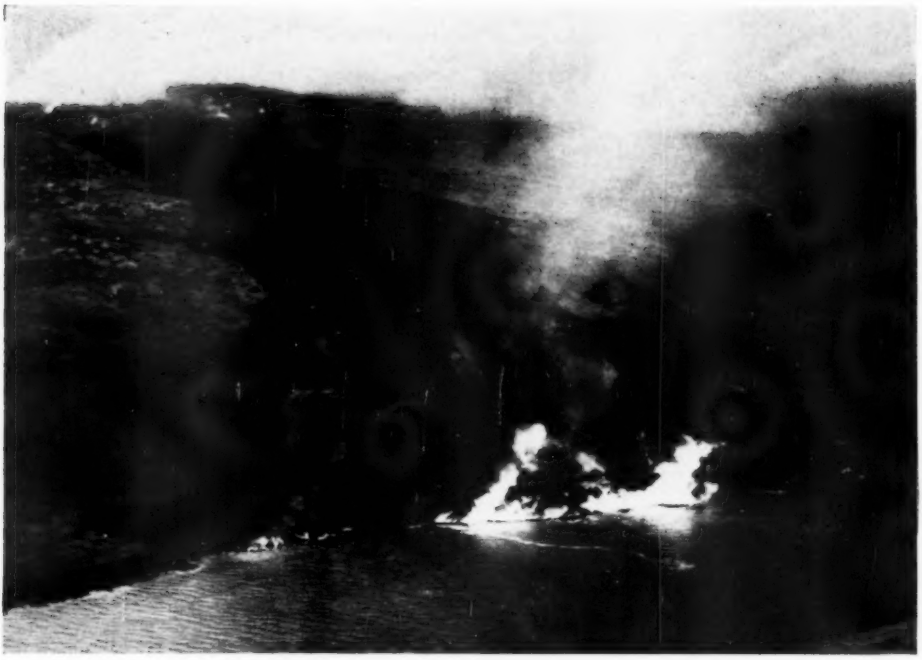
OPERATION CABOT

A multiple ship survey of the Gulf Stream took place during the month of June, 1950, when six vessels manned by more than 350 scientists and seamen conducted simultaneous observations over the 1,500-mile area between Cape Hatteras and the Grand Banks of Newfoundland.

The main purpose of the expedition was to learn how the Gulf Stream behaves over a large area. Recent studies have brought to light the fact that the current snakes through the ocean like a large river, making loops that travel at the rate of one to two miles per hour.

The ships are fitted out with a battery of special instruments developed recently. The "front" or "cold wall" of the Gulf Stream can be found with the aid of a bathythermograph, a diving thermometer that records temperatures down to a depth of 1,000 feet. This recorder is lowered every half hour, and a continuous profile of the water's thermal structure is plotted in the ship's laboratories.

Meteorological data are also being collected from the ships as well as from a U. S. Navy plane. It is believed that a weather front is associated with the "front" of the Gulf Stream, but heretofore it has been impractical to obtain simultaneous observations from a large ocean area.



The stream of black lava in this picture, taken June 4, 1950, has reached the southwestern coast of the island of Hawaii, after a journey of many miles from Mauna Loa's latest eruption. Geysers and fumes rise into the air as the lava, reputed to have a temperature of 2,000 degrees centigrade, makes the sea water boil to form the dense vapor that shrouds the upper part of the scene. This may have been a contributing source of the haze over much of the Pacific Ocean a few days later. Associated Press photograph.

A PHENOMENAL HAZE IN THE PACIFIC

R. H. SIMPSON, OFFICIAL-IN-CHARGE, USWB, HONOLULU

EXCELLENT visibility characterizes the trade-wind belt of the central Pacific. It is not uncommon to see the mountains on West Maui from a sea-level position on the island of Oahu, a distance of more than 70 miles. During periods of stronger trade winds, haze from sea salt in the air may reduce the visibility to seven or eight miles in exceptional cases, but rarely below this figure.

During the second and third weeks of June, however, a curious dry haze reduced visibility to values below three miles over vast areas of the Pacific between 10° and 30° north latitude. The haze was intermittent, and the longest continuous period of low visibility at any station was 72 hours. Honolulu, Midway, Wake, and Guam were all affected simultaneously, and at Johnston Island, Hilo, Upolu Point, Lihue, and Kona, the visibility was reduced to one mile. The S.S. *Hawaiian Citizen* encountered the haze on June 9th some 1,500 miles east southeast of Hawaii, and for several days thereafter the ship was unable to navigate celestially, as a result of the reduction of visibility from the haze in the sky.

The first reports of the haze were from Johnston Island on June 8th at midnight (GCT). Visibility there dropped from greater than 15 to two miles in less than three hours, but improved again to 14 miles before the day was over. Wake was the next to be affected, and in less than 18 hours later Midway and the Hawaiian Islands experienced the haze for the first time; it lasted at most places for the succeeding two

or three days. There followed nearly a week of good visibility at Hawaii, and on June 21st and 22nd visibility lowered again.

In Honolulu, the haze appeared similar to the Los Angeles smog, but the public health service received no reports of unusual irritation of eyes and mucous membranes — the air pollution apparently contained no appreciable concentration of irritants.

Clouds could be seen but dimly through the haze. The sun, which became obscured when less than 15 degrees above the horizon, was a greasy yellow near the zenith and a dull red when low in the sky. Many observers noted a large cluster of sunspots visible to the naked eye. The relative humidity followed a normal to drier-than-normal diurnal pattern, falling to 48 per cent at midday when the haze was thickest.

Analyses of atmospheric samples during the haze were made by the Territorial Board of Health and the Pineapple Research Laboratories. The former used an electrostatic precipitor which indicated that the air contained from 500 to 600 times the normal number of suspended solid particles. Of these, 22 per cent were salt, many times the average amount of salt in the air. The remainder of the solid particles were insolubles of small diameter averaging 0.2 micron. In projection, these particles showed very slight Brownian movement, and slight if any flocculation. Chemical analysis revealed a total salt content of 1.35 milligrams per cubic meter, and total acid content of 1.2 milligrams per cubic meter, of which 0.6 milligram per cubic meter was sulphur dioxide and the remainder carbonic acid. The chemical analysis of the Pineapple Research Laboratories from another sample indicated a high sulphate content and a lesser amount of chloride.

During the haze phenomenon, meteorological conditions favorable for the development of a salt haze were conspicuously absent. The east Pacific anticyclone was dominant throughout the period both at the surface and aloft. Trade winds were deep in the Hawaiian area, but more southeasterly and lighter than normal. A trough persisted for much of the period between Midway and Wake. The trade-wind temperature inversion was definitely higher than usual in Hawaii and absent at Wake Island.

The most obvious source of haze particles was the Mauna Loa volcano, which was in eruption during the period. The eruption began on June 1st, but no haze was reported in the Hawaiian Islands or elsewhere until June 8th, after which time vast areas of the Pacific became affected in succession. The visibilities lowered rapidly, whereas they would have reduced gradually had there been slow settling out of volcanic material which had previously saturated the air aloft.

Mauna Loa introduced two sources of pollution in the air. Volcanic fume and ash were emitted at the 8,000-8,500-foot level, and hot lava flowing into the sea produced a huge steam cloud. The latter undoubtedly swept large quantities of sea salt into the air, as well as a myriad of finely divided particles of Aa lava which, according to volcanologists, is pulverized in the explosive reaction which results at sea (see the picture on the preceding page).

Planes arriving from the volcano area the morning of the eruption reported a tall column of volcanic effluent and cloud, extending from the 10,000-12,000-foot level on the mountain to very great heights estimated above 60,000 feet. Within 24 hours, however, the effluent was observed to be spreading out near the 14,000-foot level. The volcano has a height of 13,625 feet above sea level.

Air trajectories computed in an effort to trace the source of air parcels arriving at the several stations affected at the time visibility began lowering indicated that, in most instances, the volcano could have been the source of the haze. But the volcanic material traveled thousands of miles under conditions that apparently should have favored dispersion, yet reached the areas affected in such concentrated streaks or patches that visibility dropped to less than three miles in several hours.

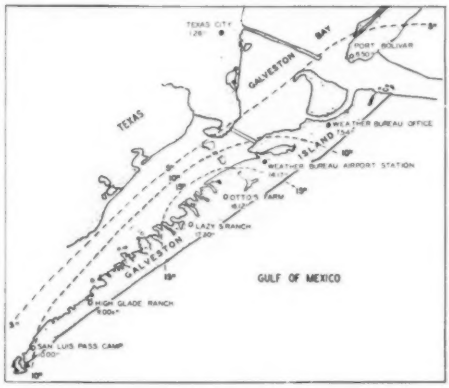
On June 6th, it was reported that a dust storm had occurred in the deserts of Southern California. Air trajectories indicated that dust from this area might have been swept into the Hawaiian region at the time the visibility lowered in haze. It appears unlikely, however, that materials from this source could have reached the points much farther west in the Pacific by the time the haze was first reported.

A street in Galveston, Texas, after the storm, June 3, 1950. Galveston *News and Tribune* photo.

Heavy Rainfall at Galveston Island—June 3-4, 1950

NEAR-RECORD rainfall occurred at several south Texas stations during the first days of June, 1950. A very unstable situation moved across the entire state of Texas, and when this trough reached the shores of the Gulf of Mexico, thunderstorms of unusual intensity developed.

The rainfall began in the Galveston area June 2nd, with frequent light rain showers during the day, and up to midnight the total was only 0.13 inch. Then on June 3rd the thunderstorm activity began, with rain starting to fall at 1:35 a.m., and continued until 8:30 a.m. Another shower, but light, began at 10:05 a.m., and ended at 10:20 a.m. The total recorded on June 3rd at this station was 7.41 inches.



Rainfall at various places on Galveston Island, according to official and unofficial reports. The dotted lines show approximate areas of rainfall at intervals of five inches. Chart from Galveston Weather Bureau.

At the Airport station, about six miles southwest of the city office, a total of 14.17 inches of rain fell. Measurements made at the six-hour observation periods were:

	June 2nd	June 3rd
12:30 a.m.	0.00	0.19
6:30 a.m.	0.00	5.10
12:30 p.m.	0.06	8.80
6:30 p.m.	0.02	0.00

The thunderstorm appeared to be centered in the vicinity of the Lazy S Ranch, about 13 miles southwest of the Weather Bureau office, where a "bucket survey" indicated a fall of 17.30 inches. The map shows the amounts of rain actually measured or estimated at several points on Galveston Island.

Rainfall intensities at the city office of the Weather Bureau were:

5 min.	0.53 in.	60 min.	3.18 in.
10 min.	.90 in.	80 min.	3.42 in.
15 min.	1.36 in.	100 min.	3.88 in.
20 min.	1.59 in.	120 min.	4.87 in.
30 min.	1.92 in.	150 min.	5.71 in.
45 min.	2.53 in.	180 min.	6.12 in.

The heavy rain occurred at the time of rising tide in Galveston Bay; in fact, the peak high

tide for the day was noted at 8:00 a.m. on the recording gage. Tides had been persistently above normal for two or three days due to continued fresh southeast winds off the Gulf of Mexico. Because of these two factors, the drainage system was not adequate, according to reports, to take care of the runoff, and the business district and parts of the residential section were covered with from two to four feet of water. Some business houses were flooded, as well as parked automobiles, and considerable damage was done to streets. The total amount of damage was estimated at $400,000.

During the storm, the highest wind velocity recorded at the city office of the Weather Bureau was 42 miles per hour, from the southeast at 6:40 a.m.

ERNEST CARSON, O-I-C
USWB, Galveston, Texas

TEXAS METEOROLOGY DEGREE

. The department of aeronautical engineering of the University of Texas at Austin has established a program leading to a degree of bachelor of science in meteorology, beginning in September. Thus Texas joins the University of California at Los Angeles and Florida State University at Tallahassee in offering the only full undergraduate degrees in meteorology in the southern half of the United States.

Hurricane Alert in the Bahamas

ANNUAL inspection of the weather stations of the Bahamas department of telecommunications has recently been concluded by officials of the Miami Hurricane Warning Service, and Ralph Higgs, of the United States Weather Bureau, Washington, D. C., in the company of Bahamian officials. The teamwork of many departments in the two governments during the hurricane season is an outstanding example of international cooperation to save life and property.

The more than 20 weather observing posts shown on the map are maintained throughout the 3,000 islands that compose the Bahamas group. These low exposures of coral reefs (highest point, 400 feet, on Cat Island) usually lie in the main paths of the great hurricanes that sweep northwestward from the ocean areas north of the Greater Antilles. In many cases the first confirmation of the presence of a tropical storm is the report of increasing winds, unusual tides, and falling barometer from Turks Island.

The severity of these hurricanes is well attested by the storm of September, 1947, when the wind speed at Hope Town, Abaco Island, reached an estimated 160 miles per hour when the wind instruments blew away. At that time, in his own words the observer reported: "Am digging a hole and crawling in."

Probably the most memorable storm in the islands' history was the Great Bahamas Hurricane of 1866. This was a storm of wide extent and great severity, and the loss of life, land property, and ships was especially heavy, for the storm occurred just prior to the institution of storm warning services in the United States and the West Indies. The eye of the storm passed directly over the capital city of Nassau, located on New Providence Island. At 8:00 p.m., the barometer fell to 27.70 inches, and the center of the vortex remained over the city from 7:20 p.m. to 8:50 p.m., from which it was concluded that the center was 23 miles in diameter. Shifting winds of hurricane force did great harbor damage.

This map shows the weather reporting stations on hurricane alert in the Bahama Islands, including two automatic stations at the entrance to Florida Straits. Reports to Nassau are relayed to Hurricane Weather Central at Miami. USWB chart.

Wendell Kilmer, of the Long Island Weathermen, at his desk in his weather station. The equipment includes a radio receiver for the reception of weather reports.

LONG ISLAND WEATHERMEN

A NEW GROUP of amateur weathermen has recently organized with a center of activity in Nassau County, New York. In the words of the founders, the Long Island Weathermen "wanted to get together a group of people interested in weather to meet for the purpose of mutual education and better understanding of weather and associated subjects."

The original six members who formed the group were Wendell Kilmer, co-operative observer of Hempstead; James McGuire, New York Weather Bureau; Ernest Rosenberg, AWA'er of Hempstead; Frank Martine, AWA'er of Brooklyn; Oliver West, co-operative observer at Malverne; and Harold Duflocq, formerly with the USWB, of Cranford, N. J. About 20 new members have been recently added.

Notices of the society's activities have been carried in feature articles in the Nassau County press, and over the radio by Nemo, the well-known and respected weatherman of station WOR.

Three public meetings have been held, with an attendance averaging 25 men and women. The first meeting heard an address by James McGuire on "Trends in Thought in Forecasting in the Weather Bureau." Next, Ernest Christie, official-in-charge of the New York Weather Bureau, spoke on "Thunderstorms." The most recent meeting, scheduled for July 22nd, was to hear a talk on "Weather Bureau Services and Facilities at La Guardia," by the official-in-charge there, Louis Harmantas.

The meetings, so far, have been held at the Central Nassau weather station located in the home of Wendell Kilmer. A long-time AWA member, he has followed the weather as a hobby for more than 20 years. After a Marine Corps career in radar in World War II, he built a very complete weather station in his home, its equipment including mercurial barometer, recording barometer, maximum-minimum thermometers, hygrothermograph, sling psychrometer, rain gage, direct-reading wind vane and anemometer. Mr. Kilmer takes four daily observations and maintains a daily forecast-

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ing service for his friends and neighbors.

All persons interested in the weather in Nassau County and vicinity are invited to get in touch with the Long Island Weathermen in care of Wendell Kilmer, 199 Atlantic Avenue, Hempstead, New York.

THE HAY FEVER SEASON IN NEW YORK CITY

(Continued from page 79)

subsided nearly as rapidly as did the winds that deteriorated to a near-calm when a migratory high pressure system dominated the New York area within 24 hours. The dryness that followed the passage of the main north-south frontal system also had contributed to the effectiveness of the pollen.

Factors other than winds, such as droughts, abundance of rainfall, and amounts of sunshine, must be considered. Retardation in the growth of the ragweed plant may limit the periodicity of heavy seasonal pollen counts. Strong winds during the early growing season will not have the same effect they produce during the "ripe" period. Close cooperation, therefore, between meteorologists and horticultural experts is a prerequisite to success in forecasting high pollen counts for any particular area.

How can the meteorologists best help the doctors? Back in 1931, Durham, a pioneer in the study of atmospheric pollen density, stated, "Allergists should be prognosticators." In this age of specialization, allergists can hardly be expected to develop skill in weather forecasting, though they can learn the causes of high pollen counts and develop a weather consciousness. On the other hand, meteorologists can be expected to develop the necessary skill in forecasting the factors which contribute to air pollution, and certainly can aid the allergists and horticulturists in explaining the pollen data which they obtain.

As pollen-observation programs expand, opportunities will develop for amateur weather observers to assist in obtaining pollen sampling during the summer season. Research allergists and public health authorities would certainly appreciate efforts to obtain more pollen samplings, particularly in conjunction with meteorological observations. Any Amateur Weathermen of America members interested in assisting should notify their local boards of health.

FORECASTING THE WEATHER

The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft

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EXTENDED FORECAST SECTION, UNITED STATES WEATHER BUREAU

STUDIES OF WINTER PRECIPITATION

THE CONCLUDING three articles in this series will be concerned with the relationship between precipitation and circulation patterns for the winter season only, since most recent research has been concerned with winter data, because the circulation and anomaly features are most pronounced in that season. However, further investigation of the other seasons is planned.

The origin, transport, and release of moisture are all integral parts of the problem. Of these we shall be chiefly concerned with the release, since this is the most complex phase. The fact that precipitation must be initiated and ultimately terminated means that by its very nature it is discontinuous — it either falls at a station or it does not. In this respect, precipitation differs from temperature, which is continuous. It is partly this discontinuity in character that makes precipitation more difficult to forecast and makes a poor forecast so conspicuous.

The principal sources of moisture from which United States precipitation results are the adjacent large bodies of water. The Pacific, the Gulf of Mexico, and to a lesser extent the Atlantic and the Great Lakes, supply the greater part of our moisture by evaporation from their surfaces. The warmer the water surface, the faster the evaporation will tend to progress, other things being equal. Even more important, the warmer the air, the more water vapor can exist without condensation taking place. Because air temperature normally decreases rapidly with height, the major portion of wintertime moisture is transported to and over the United States in levels below 15,000 feet. This moisture is for the most part invisible water vapor, although some is in the form of clouds of either water droplets or ice crystals. The transport of water vapor from the above source regions to the United States is effected by the varying circulation patterns in the lower atmospheric levels.

The remaining steps in the process are the transformation of the water vapor into clouds and its release as falling precipitation.* As moisture-laden air is cooled beyond a certain point, some of the water vapor present condenses in the form of cloud droplets or ice crystals. Whether or not this visible moisture falls to the ground as precipitation is a problem of great complexity. One can reasonably assume that if sufficient moisture is present, and extended vertical lifting occurs, appreciable precipitation will result. This assumption seems to be justified by experience, and the synoptic meteorologist devotes his attention to the availability of moisture and to the cooling process.

Effective cooling in the atmosphere is usually the result of large-scale lifting. The air expands when rising and cools as it expands. Downward motion results in warming. The more obvious causes of effective vertical motion are briefly enumerated below:

1. Flow of air over a mountain (orographic) barrier causes the air to cool as it ascends the windward slope and warm as it descends the leeward side.

2. Warm air glides forward and upward in advance of a surface warm front. A cold front wedges in under the warm air and forces it aloft.

3. A cyclonic depression is usually characterized both by these frontal processes and by lower level winds which, in part because of surface friction, spiral counterclockwise inward, thus causing convergence of the air and forcing it to rise. This effect is to a degree also present in the trough (usually extending south of the depression). Thus one may expect some upward vertical motion in most counterclockwise circulations. Downward vertical motion is common to high pressure areas (anticyclones) or ridges. In these the winds flow clockwise around the center and spiral outward in the lower levels. This causes the air to diverge from the center and allows it to sink. In view of the vertical motions associated with each, it is not difficult to see why we have come to relate wet, cloudy days with low pressure areas and dry, clear days with high pressure areas.

4. Southerly flow is frequently associated with precipitation. This is true first because such flow normally precedes the trough or low center passage where convergence and frontal lifting are present. Also, for the eastern half of the United States, southerly flow brings up warm, relatively moist air from the Gulf of Mexico.

There are other flow patterns that have characteristic vertical motions; these will be men-

*One early reference to this hydrologic cycle may be found in *Ecclesiastes* 1:7: "All the rivers run into the sea; yet the sea is not full: unto the place from whence the rivers come, thither they return again."

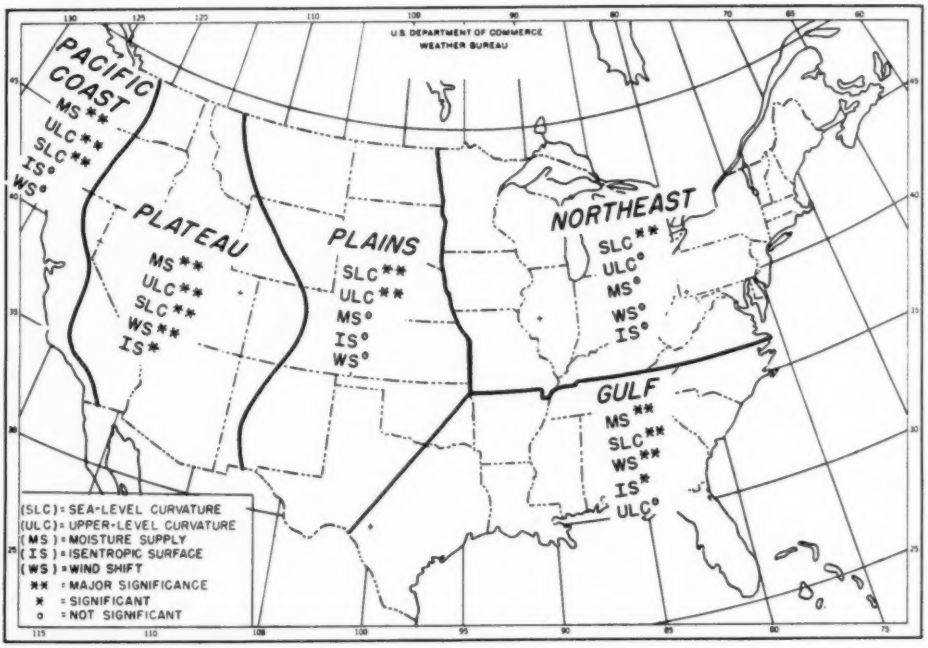


Fig. 1. The association of five parameters with winter precipitation over the United States (after Smith). They are listed in order of decreasing association in each region, and the significance of the relationship is shown by the symbol after each parameter, described in the key in the lower left corner of the chart.

tioned where appropriate. Since one or more of these factors may operate in unison or may counteract each other, their net effect on precipitation is difficult to assess, particularly as refined measurements of vertical motion are not practicable.

The above factors have long been considered by forecasters when preparing precipitation forecasts with the aid of prognostic charts. For example, in the Extended Forecast Section of the Weather Bureau, forecasts are made by studying the past circulation and then prognosticating the succeeding average or mean weather patterns for sea level and 700-mb level (about 10,000 feet). The mean charts are particularly applicable, since they obliterate the minor irregularities in the daily flow patterns and focus attention upon the major cyclonic and anticyclonic centers. These mean "centers of action" normally move and develop much more slowly than the cyclones and anticyclones on daily maps and are more tractable for purposes of extended forecasting. Moreover, the sustained flow represented by mean maps affords an investigator the opportunity to learn how **on the average** some of the foregoing factors are related to precipitation.

Early in the history of modern extended forecasting, these qualitative procedures were augmented by a project to test statistically the relationship between various parameters and precipitation. The first of this kind was made by K. E. Smith. ("Five-day precipitation patterns in the U. S. in relation to surface and upper-air charts." M. I. T. masters thesis, 1941, unpublished.) The United States was divided into the five relatively homogeneous areas indicated in Fig. 1. This was done because of the variations of elevation, terrain, and moisture source. Using the 5-day precipitation totals and the associated 5-day mean charts at sea level and 10,000 feet for the winter 1940-41, five chosen factors were measured for each of the selected areas and then related to the concomitant precipitation. The parameters tested were:

1. Curvature of the isobars on the mean-sea-level pressure chart. This included the type of curvature (cyclonic or anticyclonic) and the degree or intensity of curvature.

2. The curvature of the mean isobars on the 10,000-foot chart (similar to 1).

3. The shift in geostrophic wind direction from the surface to 10,000 feet. The underlying thought here was that the turning of the wind clockwise with height often indicates the

overrunning of a cold surface high by warmer air. Similarly, counterclockwise shifting suggests downslope motion.

4. Moisture supply as indicated on a selected mean isentropic chart. This chart pictures the sloping (isentropic) surface along which the air with its moisture can normally be expected to move. The supply was rated good, average, or fair as compared to normal moisture values.

5. Upslope or downslope motion as indicated by winds and contours of elevation on the isentropic chart. This was classified as good, moderate upslope or downslope, or no slope.

After the observed precipitation over limited areas of the subdivisions had been classified as heavy, moderate, or light, the heavy and light cases were tested statistically to find their association with the various parameters. (The precipitation classes, heavy, moderate, and light, are constructed so that each class normally occurs one third of the time and thereby has equal probability of occurrence.)

While the results indicated that all of the above-named factors were associated with precipitation, the relationship was not statistically significant in all cases. More meaningful associations area by area are indicated in Fig. 1. Over the Pacific coast, plateau, and Gulf regions, the moisture supply was the most effective parameter. In the Northeast and the northern plains the wintertime precipitation processes seemed to take place below the chosen isentropic level, and perhaps other factors such as upslope motion and overrunning were more important, so that little could be learned about the effect of moisture.

The curvatures (both sea level and aloft) were found to be intimately associated with precipitation, cyclonic circulation with heavy and anticyclonic with light. The more intense the curvature, the better was the association and the larger the area covered by the associated precipitation class. The upper-level curvature was slightly more significant than the surface curvature over the Pacific coast and plateau, with the reverse being true in the other three areas. The change in wind direction between sea level and 10,000 feet worked fairly well over the plateau and the Gulf areas but was of little significance elsewhere. Finally, a relationship was found between upslope and downslope motion on the isentropic surface and precipitation. However, it was often quite weak.

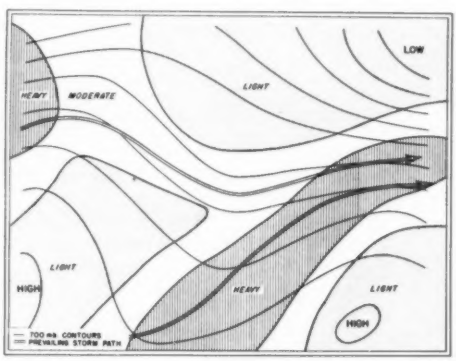


Fig. 2. A schematic model (after Klein, 1948) showing the relation of precipitation areas and storm paths to the upper-level wave pattern in winter. The 700-mb contours are solid lines; double lines with arrows show storm paths. Dotted areas show light precipitation; white, moderate; and striped, heavy.

Smith's research pointed up a method of interpreting circulation patterns in terms of precipitation and delineated areally the degree of usefulness of the various factors. Of course, other factors remained unevaluated, and the data were limited to only one winter. Moreover, the various factors were not combined in such a way that a precipitation forecast could be objectively made from a given set of maps.

A more specific and detailed study was later made by W. H. Klein,* who was interested more particularly in the relation between the upper-level wave pattern, which appears from 10,000 to at least 30,000 feet, and the associated precipitation in the Tennessee valley. Insofar as this region is comparable orographically and in orientation of moisture source to other areas in the eastern United States, the results of this work can be applied to a much larger area.

Klein investigated the occurrences of light, moderate, and heavy precipitation in the Tennessee valley for 5-day mean periods during six winters in relation to their position relative to the mean wave system at 10,000 feet. The results are best demonstrated by the schematic precipitation model of Fig. 2. It shows that light precipitation occurs most frequently behind the trough, near the center of the anticyclone aloft, and ahead of the ridge; heavy is typical in the zone ahead of the trough and in the rear of the ridge; and moderate predominates near the trough and ridge lines (lines of minimum and maximum contour latitude). The occurrence of a restricted area of heavy rain near the ridge (right-hand portion of Fig. 2) should be noted. This is related to "confluence" or the flowing-together of cold and warm air masses. The study included circulation features upstream (in the westerlies) from the Tennessee valley. This "expansion of horizons" in the search for pertinent parameters was an improvement over Smith's use of purely localized indices. The findings were systematized, so that given an upper-level pattern one could objectively calculate the most likely precipitation class.

In addition to the schematic model, which

*W. H. Klein, "Winter Precipitation as Related to the 700-Mb Circulation." **Bulletin** Amer. Met. Soc., **29**, 9, 439-453, November, 1948.

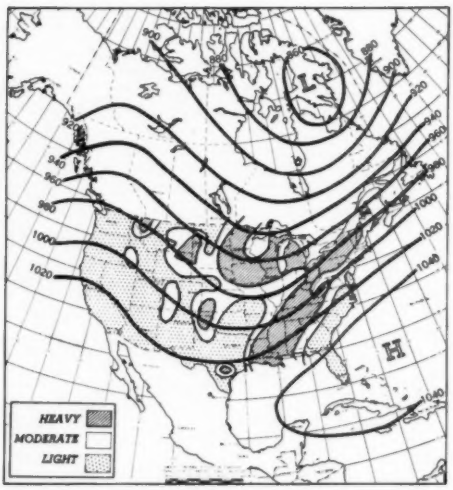


Fig. 3. An example of the relation between observed upper-level flow pattern and concurrent precipitation, March 6-10, 1946. The solid lines are 700-mb contours for each 200 feet, expressed in 20's of feet.

has proved most useful, several other practical relationships were statistically established. These findings indicated:

1. The effectiveness of southerly flow in producing precipitation and northerly flow in suppressing it.

2. The relation of storm path to the upper-level pattern (see Fig. 2 where double curves with arrows indicate average storm paths). Storms were found to be frequent in troughs tilting from southwest in lower latitudes to northeast in higher latitudes and in regions of strong confluence of warm and cold air flow (right portion of Fig. 2).

3. The weak association between upper-level curvature and precipitation for the southeastern United States (also found by Smith).

4. The relation between precipitation and position relative to the 10,000-foot wave pattern. Heavy is most frequent about one half the distance from the trough to the next ridge downstream; light is most frequent about halfway from the ridge to the next trough downstream.

In view of what was said at the beginning of this article about the relation of vertical motion to cyclonic and anticyclonic curvature, it may seem a bit surprising to find that the extremes of precipitation do not occur at the trough and ridge lines (where curvature is the greatest) but somewhat to the east. This may be accounted for in part by the tendency for troughs and ridges, at least during winter, to slope to the east in going from higher to lower elevations. Thus a trough at 700 mb may be associated with a sea-level low pressure center which is roughly 500 miles to the east. In view of the additional fact that most of the available moisture is located at lower atmospheric levels, it is not surprising to find the centers of maximum and minimum precipitation east of the circulation features aloft.

The several limitations of Klein's results are not too restrictive. The general applicability of the schematic model in other portions of the eastern United States has been demonstrated by experience. However, some further testing for other areas of varying similarity should be made with particular attention devoted to the singularities which may have been introduced by the orographic effect of the Tennessee valley. The other limitations are related to the localized nature of the parameters (although Klein did consider a broader scale field than Smith) and the rather involved technique necessary in making a purely objective forecast.

Fig. 3 gives some idea of how an observed case compares with the schematic model and other findings of Klein. This map was chosen primarily because the trough location and symmetry resembled that shown in Klein's model. One sees immediately that the correspondence is not exact. The major portion of the heavy area is east of the trough aloft, as expected. It tapers off quite rapidly to light in the southeast; this tendency is perhaps aided by some downslope motion east of the Appalachians. By analogous reasoning, the light precipitation through the trough in Texas is in part due to downslope motion east of the divide and to inadequate moisture supply after the long traverse of the air from the Pacific. Considerations such as these must influence the forecaster in his use of the model. While the schematic concept is obviously helpful, it must eventually give way to a more objective interpretation.

It is hoped that the discussion of precipitation characteristics given in this article has established a common ground with the reader as to the gross aspects of the physical process. Two future articles will describe more recent research that extends the work of Smith and Klein in relating upper-level winter circulations with precipitation in the United States.

This article was written by Harry F. Hawkins, Jr.

ANTI-WEATHERWISE

A disgruntled resort proprietor at Weston-Super-Mare in England recently announced that he was going to seek an injunction against broadcasts of unfavorable weather by the BBC before holidays because they are bad for business.

On a recent Sunday the broadcast forecast called for a dull, cold, showery day, but, he complained, "As it was, we had 12 hours of sunshine and no rain. These forecasts do untold harm to hundreds of small traders and to seaside towns generally and, in my opinion, keep away thousands of visitors."

WORKSHOP FOR WEATHERMEN

CONDUCTED BY CHARLES A. LAIRD

How to Construct A Motor-driven Psychrometer

THE PSYCHROMETER, for determining relative humidity, dew point, and vapor pressure, consists of two thermometers, one of which has its bulb covered with a moistened layer of cloth. Evaporation of water from the cloth (usually called the wick) has a cooling effect, and the drier the air, the greater the rate of cooling. By determining the dry-bulb or air temperature, and noting the difference between the readings of the two thermometers, relative humidity, dew point, and vapor pressure may be found. These values may be determined by formulae (see "The Wet Bulb Without Tables," WEATHERWISE, **2**, 4, Aug., 1949, p. 92), or by resorting to tables such as are printed in Weather Bureau **Circular** No. 235, obtainable from the Superintendent of Documents, Washington, D. C., price 15 cents.

A psychrometer must have its wet bulb adequately ventilated; otherwise, the air surrounding the wick may become partially saturated and erroneous readings may result. In the psychrometer shown here, a small fan is rotated by an electric motor, drawing a stream of air through a metal tube and ventilating both the wet and dry bulbs.

The whole assembly is mounted on a support consisting of a baseboard and an upright backboard fastened to it with screws or nails. Obtain two good thermometers, constructed so that you may cut away the lower end of their wood or metal backs, letting the bulbs and a portion of their stems extend downward for insertion in the ventilation tube. These thermometers are fastened to wooden blocks, using small wood screws. The blocks are, in turn, mounted on the upright wooden backboard.

The ventilation tube has a 2″ inside diameter. A larger size will serve, if the fan and motor are larger than the ones shown here. You may make the tube of copper, brass, galvanized iron or, better still, a length of standard brass tubing. The tube should be about 6″ long and mounted on two wooden blocks, cut to fit the tube.

A small motor drives the fan. One of the small motors of the type used to defrost automobile windshields may be employed. This may be operated by a transformer or dry-cell batteries. The motor is mounted on a block of the correct height to put its shaft in the center of the ventilation tube. Use a wood or metal hub for the fan, slotted to receive two or four fan blades. The fan must have an outside diameter that will allow it to rotate inside the ventilation tube, about ½″ from the tube's right end. The direction of rotation must be such that air will be pulled through the tube, flowing across the dry bulb first.

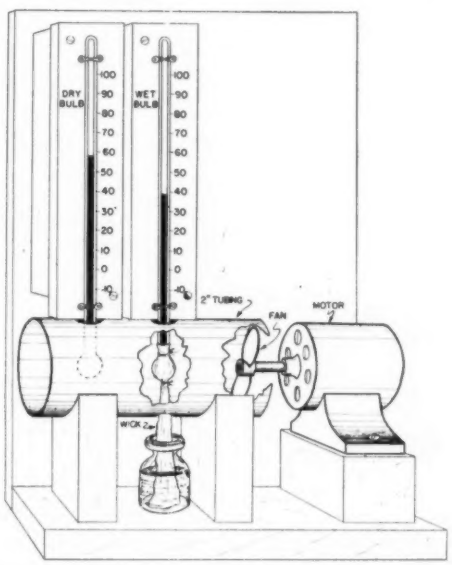
Holes must be drilled in the tube so that the thermometer bulbs and a portion of their stems will project into the tube, as shown in the drawing. Dimensions are not given in the drawing, as the size of the instrument will depend on the type of thermometers used, the sizes of motor and fan, and so on.

The wet-bulb thermometer has its bulb covered with clean muslin. A muslin strip, wide enough to go about 1-1/3 times around the bulb, is tied above and below the bulb with thread, in the manner shown. The muslin strip should be long enough to extend through a hole in the bottom of the ventilation tube and into a small bottle of clean water.

This instrument is capable of giving continuous wet- and dry-bulb readings as long as there is adequate water in the bottle to keep the wick moist clear to its top. In very dry weather, you may find that the water has evaporated before it reaches the top of the wick. On these occasions, put water directly on the wet bulb, using an eye dropper, small brush, or a length of glass tubing. This should be done, of course, shortly before a reading.

Obviously, when the air temperature is below freezing, it will not be possible to use the water bottle and a long wick. Use a short wick, just covering the bulb and a portion of the stem, and wet it directly as described above. The wet bulb should have a thin layer of ice on it.

The wick should be changed about once a week, as after a time it will collect dirt and repel water. Use clean, new muslin, and wash it thoroughly before use to remove the sizing.



THE THUNDERSTORM

U. S. Weather Bureau. Superintendent of Documents, Washington 25, D. C., 1950. 287 pages. $2.25.

FOLLOWING World War II, the Air Force, Navy, National Advisory Committee for Aeronautics, and Weather Bureau joined forces in an effort thoroughly to explore thunderstorms, one of the major weather hazards to aircraft. The Thunderstorm Project, under the direction of Dr. H. R. Byers, of the University of Chicago, using facilities and personnel of the above agencies and funds appropriated by Congress, devoted two summers to an intensive observational program, conducted in Florida in 1946, and in Ohio in 1947. Data obtained were critically analyzed by a large staff of experts with the result that much new knowledge of the structure and behavior of these storms has been brought to light, and this volume "is to be considered as the final report of the present phase of the Thunderstorm Project."

The book opens with an account of the project's history, a summary of the design of the observational system, a description of the areas of operation, and a resume of the character of data obtained.

Part One, occupying about half of the book, is devoted to a description of the thunderstorm. Subdivided into eight chapters, this section deals in a comprehensive manner with almost every aspect of these storms in the light of the investigations of the project. The liberal use of well-chosen tables, charts, diagrams, and radar scope photographs, combined with the excellent text, results in a presentation of the subject which is at once thorough and easily grasped by the reader.

One chapter, "Thunderstorm Structure and Circulation," embodies two of the great contributions made by the project — the development of knowledge of both the cellular structure of thunderstorms and the existence and importance of the dissipating or downdraft stage of cell evolution. Entrainment of environment air in cumulus and cumulonimbus clouds, a comparatively recent concept, is discussed in the light of project research.

The surface weather of the thunderstorm is the topic covered in another chapter. Rainfall, wind, temperature, pressure, and humidity are each considered, and the text is illustrated with reproductions of record traces obtained by the network of surface stations. Also discussed are the effects of these elements in stimulating the development of new convective cells adjacent to existing storms. Since most of us experience thunderstorms at the earth's surface, this chapter will prove useful as a guide to the observation and enjoyment of these storms.

The other chapters of this section include treatment of turbulence and hydrometeors, electric fields, storm motion and other effects of the surrounding atmospheric circulation, squall lines and areas conducive to thunderstorm development. Particularly interesting is "The Thunderstorm as Revealed by Radar." Radar can probably be considered as the most potent observational tool employed by the project, as through its use all other observations could be tied together to form a complete "play-by-play" picture of thunderstorms in action.

The second part contains a discussion of the effect of thunderstorm conditions on airplane operations in flight and on the ground, and presents the conclusions of the project with respect to such operations.

Part Three is devoted to the presentation of analyzed data obtained from five thunderstorm situations and examples of three squall lines. With this material the reader is given the opportunity of following step by step the procedure used in arriving at the conclusions set forth in the first two parts. Two of the examples of thunderstorms include data obtained both at the ground and from airplanes, two include airplane data only, and the last presents special features obtained at the surface network only. A complete description of the development of each situation accompanies the material.

An appendix gives details of the instruments and other equipment used by the project. The more unusual instruments are described in considerable detail. This section of the book will have a definite appeal for those whose interests lie in the direction of instrumentation. A list of 63 references is provided, of which nine are in a foreign language.

Dr. Byers and all those associated with the Thunderstorm Project and the publication of its results are to be congratulated on this excellent work. Such an authoritative book should be a part of the library of all those who are interested in weather. Amateur and professional alike will find it extremely interesting and informative.

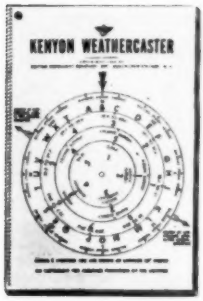
HARRY H. LARKIN, JR.
Western New York Weather Society
Buffalo, New York

NEW BOOKS RECEIVED

ATMOSPHERIC TURBULENCE, *O. G. Sutton*, 1950, *Wiley*. 108 pages. $1.50.

This study, first published in Great Britain, is now available in America. Professor Sutton discusses this pressing meteorological problem by viewing it as a branch of mathematical physics. The work deals only with the theory of turbulence and confines attention to the lower layers of the atmosphere.

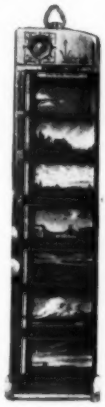
Forecasting Aids



901 WEATHERCASTER — This handy booklet translates current weather conditions into a weather forecast. Four plastic dials are adjusted by the observer to match current conditions. The four elements are: sky condition, barometric tendency, height of the barometer, and wind direction. A key number then enables one to read the appropriate forecast from inner page tables. Size: 6½ x 9 inches. **$5.00**

901

902 WEATHER GUIDE — The basic concept of the Weather Guide is that the major factors determining short period weather changes are revealed by the cloud formations in the sky and the wind direction on the ground. One merely selects the cloud picture most nearly matching current conditions, sets the wind arrow opposite the cloud picture, and reads off the forecast. The Weather Guide comes in seven models for use in each of seven zones of the United States. Size: 8 x 2 x 1 inches. **$12.50**



902

306-8

306 METEOROLOGICAL BAROMETER—U.S. Weather Bureau type. Contains best-quality movement. Special aneroid cell is temperature compensated. Open-face silver dial has double scale with graduations to 0.02 inch and to one millibar. Adjustable pointer for comparative readings. Overall diameter, 5¼ inches; thickness 2½ inches. Weight 1 lb. 11 oz. For use between sea level and 3,000 feet. **$30.00**

307 METEOROLOGICAL BAROMETER for medium altitudes. Same as #306 but for use between 2,900 and 7,100 feet. **$35.00**

308 METEOROLOGICAL BAROMETER for high altitudes. Same as #306 but for use between 5,950 and 11,800 feet. **$35.00**

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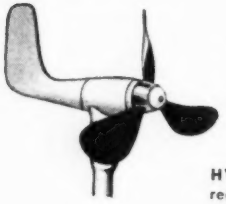

THE AEROVANE* TRANSMITTER—Combines wind speed and direction components in one unit. It consists of a three-bladed molded rotor to measure wind speed, and a streamlined vane for wind direction.

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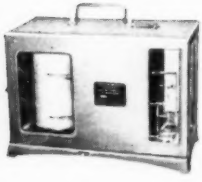

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